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Content Validation and Evaluation of an Endovascular Teamwork Assessment Tool

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WHAT THIS PAPER ADDS

This study presents a novel assessment tool to capture the quality of interdisciplinary teamwork in endovascular surgery; the Endovascular Observational Teamwork Assessment for Surgery (Endo-OTAS). Endo-OTAS has been systematically developed, content validated and evaluated. Key behaviours that contribute to effective teamwork and patient safety in endovascular surgery have been identified. This study enables systematic objective assessment of the quality of team performance during endovascular procedures.

Robust assessment and training of team skills using Endo-OTAS has the potential to facilitate improvements in interdisciplinary team performance and, in turn, clinical outcomes.

Objective/Background: To modify, content validate, and evaluate a teamwork assessment tool for use in endovascular surgery.

Methods: A multistage, multimethod study was conducted. Stage 1 included expert review and modification of the existing Observational Teamwork Assessment for Surgery (OTAS) tool. Stage 2 included identification of additional exemplar behaviours contributing to effective teamwork and enhanced patient safety in endovascular surgery (using real-time observation, focus groups, and semistructured interviews of multidisciplinary teams). Stage 3 included content validation of exemplar behaviours using expert consensus according to established psychometric recommendations and evaluation of structure, content, feasibility, and usability of the Endovascular Observational Teamwork Assessment Tool (Endo-OTAS) by an expert multidisciplinary panel. Stage 4 included final team expert review of exemplars.

Results: OTAS core team behaviours were maintained (communication, coordination, cooperation, leadership team monitoring). Of the 114 OTAS behavioural exemplars, 19 were modified, four removed, and 39 additional endovascular-specific behaviours identified. Content validation of these 153 exemplar behaviours showed that 113/153 (73.9%) reached the predetermined Item-Content Validity Index rating for teamwork and/or patient safety. After expert team review, 140/153 (91.5%) exemplars were deemed to warrant inclusion in the tool. More than 90% of the expert panel agreed that Endo-OTAS is an appropriate teamwork assessment tool with observable behaviours. Some concerns were noted about the time required to conduct observations and provide performance feedback.

Conclusion: Endo-OTAS is a novel teamwork assessment tool, with evidence for content validity and relevance to endovascular teams. Endo-OTAS enables systematic objective assessment of the quality of team performance during endovascular procedures.

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INTRODUCTION

Over recent decades, the development of endovascular techniques has instigated a paradigm shift in the treatment of vascular disease, from open to endovascular and hybrid surgical procedures. The modern angiosuite is often staffed by teams of clinicians and technicians who have traditionally worked in disparate specialties, including interventional radiology, vascular surgery, cardiology (e.g., during

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transcatheter aortic valve insertion), neurosurgery (e.g., during carotid artery stenting), and anaesthesia. The accommodation and assimilation of team members from multiple disciplines and working environments remains the key challenge to exploit fully the potential of endovascular technology; these challenges happen suddenly in emergency procedures, where logistical requirements add another layer of complexity and, where in some instances, ad hoc teams have to work together.[1]

Nontechnical skills have been described as social (communication, teamwork), cognitive (decision-making, situational awareness), and personal resource (coping with fatigue and stress) skills that complement technical performance and contribute to safety and efficiency. Evidence exists that improving teamwork in the operating theatre is associated with a reduction in morbidity and mortality.[2,3]

Adverse events have been shown to be more prevalent during vascular procedures in comparison with other surgical operations.[4] Failures in patient safety occur frequently, with significantly more errors occurring during hybrid surgical/endovascular procedures compared with open vascular surgery.[5] Communication failures are more common (21.0%) than failures in technical and psychomotor skills (9.0%).[5] Improving teamwork, through preprocedural team rehearsal, can significantly reduce errors made in procedures.[6,7]

Training programmes using immersive virtual reality simulation have recently been developed to target the technical and nontechnical skills of endovascular teams.[8,9] However, owing to the lack of robust teamwork assessment measurement tools that capture the complexities of working within an endovascular team, the evaluation of the effectiveness of these team training programmes has been limited to the impact on technical performance,[8] and the teams' own perceptions of the usefulness and value of such training on teamwork and patient safety.[9]

Assessment of teamwork is critical in improving patient safety during endovascular procedures. Assessment may encourage teams to reflect on their performance, identify deficiencies in teamwork, highlight training needs, and inform further development of teamwork training interventions. Assessment tools have been developed to capture the quality of nontechnical skills of individual members of the operating theatre team (Non-Technical Skills for Surgeons [NOTSS],[10] Anaesthetists' Non-Technical Skills [ANTS],[11] Scrub Practitioners' List of Intra-Operative Non-Technical Skills [SPLINTS][12]) and the teamwork skills of the entire team (Observational Teamwork Assessment for Surgery [OTAS]).[13] However, none of these tools has been adapted or validated for use in endovascular procedures.

The aim of this study was to modify a well-validated teamwork assessment tool, the OTAS, and provide initial validation evidence for its applicability to capture the complexities of working in a multidisciplinary endovascular team.

METHODS

Ethical approval for this study was received from the London, UK (City Road and Hampstead) National Research Ethics Committee. All participants gave consent to participate in the study.

A multistage, mixed-method approach was used to systematically modify, content validate, and evaluate the Endovascular OTAS tool (Endo-OTAS).

Stage 1: modification of the OTAS tool

The OTAS tool was used to develop a teamwork assessment tool specific to endovascular procedures (Endo-OTAS). OTAS assesses five elements of teamwork: communication, coordination, cooperation/back-up behaviour, leadership, and team monitoring/situational awareness. Each teamwork behaviour is rated on a 7-point scale (0—6) with higher scores indicating better teamwork. To guide behavioural ratings, OTAS contains 114 "exemplar" behaviours: these are observable behaviours that contribute to teamwork and patient safety associated with each one of the five core team behaviours above, each of the surgical subteams (surgical, anaesthetic, and nursing), and each of the operative phases (pre-, intra-, and postoperative).[13,14] The structure of OTAS and each exemplar behaviour was reviewed by a psychologist and a vascular surgeon to identify and make necessary modifications, and to ensure applicability to endovascular procedures. For example, the OTAS exemplar behaviour "Arrange stack appropriately for laparoscopic operation" was removed as the behaviour was deemed irrelevant to endovascular procedures.

Stage 2: identification of endovascular-specific exemplar behaviours

To identify additional teamwork behaviours specific to endovascular procedures, a multimethod approach was employed.

Real-time observations. Endovascular procedures were observed using direct, real-time observations. Field notes of exemplar behaviours were recorded.

Focus group with subject matter experts. A semi-structured focus group with subject matter experts (SMEs; i.e., senior, experienced endovascular surgical team members, consisting of one surgeon, one radiologist, three radiographers, and two nurses) was conducted to identify exemplar behaviours (see Appendix 1 for topic guide).

Interviews with SMEs. Six individual semi-structured interviews with SMEs were conducted (see Appendix 1 for topic guide). Using purposive and convenience sampling, one surgeon, three anaesthetists, one radiologist, and one scrub nurse were recruited.

Stage 3: exemplar behaviour content validation and Endo-OTAS evaluation via SME consensus

Content validation. A structured survey was designed to assess the content validity of the exemplar behaviours identified in stages 1 and 2. Content validity is defined as "whether or not the items sampled for inclusion on the tool adequately represent the domain of content addressed by

the instrument".[15] Twelve SMEs assessed the content validity of the 153 exemplar behaviours. Experts from three endovascular centres (London, UK; Ghent, Belgium; Portland, USA) were recruited based on their clinical experience/seniority: four consultant vascular/endovascular surgeons (1—6 years at consultant or equivalent grade); three consultant anaesthetists (0.5—8 years at current grade); two consultant (or equivalent) radiologists (1—13 years at current grade); two theatre nurses (Bands 5 and 7); and one Operating Department Practitioner (Band 5) formed the expert panel. Eight of 12 (66.7%) SMEs had a further track record of research in team performance and clinical processes/outcomes research in vascular/endovascular surgery, evidenced by peer-reviewed publications.

SMEs reviewed and independently rated whether they believed each of the exemplar behaviours contributes positively to (1) teamwork and (2) patient safety in endovascular surgery, using a 5-point Likert scale (1 = not at all important; 5 = extremely important). SMEs were provided with scientific definitions of teamwork ("the interdependent components of performance required to effectively coordinate the performance of multiple individuals")[16] and patient safety ("the avoidance, prevention and amelioration of adverse outcomes or injuries stemming from the process of healthcare").[17]

Two Item-Content Validity Index (I-CVI) metrics were computed: (1) I-CVI for teamwork and (2) I-CVI for patient safety. Higher I-CVIs indicate high expert agreement that the exemplar behaviour is important and thus has content validity. Exemplar behaviours that reached or exceeded a predetermined I-CVI criterion of $\geq$ 0.78 on either dimension assessed were automatically retained in Endo-OTAS.[18] Exemplars that failed to reach the predetermined criteria were reviewed and considered for inclusion/revision or exclusion from Endo-OTAS (see stage 4 for details). SMEs were also encouraged to list additional exemplar behaviours for inclusion in Endo-OTAS. In addition, SMEs also completed a questionnaire to evaluate the structure/content, feasibility, usability, and acceptability of Endo-OTAS.

Stage 4: final team expert review of exemplars

Exemplar behaviours that were not automatically retained for inclusion in Endo-OTAS were reviewed by two teamwork assessment experts. Exemplars with an "I-CVI somewhat lower than 0.78" were considered for inclusion and/or revision, and exemplars with "very low I-CVI values" were considered for exclusion.[18] Exemplar behaviours that received "very low I-CVI values" on both dimensions assessed (i.e., teamwork and patient safety) were automatically excluded from Endo-OTAS. An I-CVI criterion of $\leq$ 0.42 was chosen as this indicated that more than half of the SMEs deemed the exemplars to be of little or no relevance to neither teamwork nor patient safety. As current literature does not provide exact I-CVI criteria for what constitutes "somewhat lower than 0.78", all exemplars that did not meet this criterion were reviewed.

RESULTS

The entire development and content validation process for Endo-OTAS is illustrated in Fig. 1.

Stage 1: OTAS tool "structural" modification and exemplar refinement

Structural modifications were as follows. (1) OTAS "surgical team" (comprising primary operating surgeon and surgical assistant(s)) was modified to "surgical endovascular" team (comprising surgeons and/or interventional radiologists, dependent on specific centre practice). (2) "Radiographer team" was incorporated into Endo-OTAS in recognition of the contribution of radiographers (technicians) to endovascular procedures in some centres and some countries.

Exemplar modifications included the following. (1) Ninety-one of the original 114 exemplar behaviours were applicable to endovascular procedures and did not warrant any modification (e.g., verbal confirmation of procedure and intraoperative requirements). (2) Four exemplar behaviours were removed as they were not relevant to endovascular procedures (e.g., arrange stack appropriately for laparoscopic operation). (3) Seventeen exemplar behaviours warranted minimal modification to ensure that they were applicable for Endo-OTAS (e.g., scrub nurse responds effectively to requests from *surgical team* and provides smooth exchange of instruments → scrub nurse responds effectively to requests from *surgical endovascular* team and provides smooth exchange of instruments). (4) Two exemplar behaviours were significantly modified to account for the differing teamwork requirements of endovascular procedures (e.g., provides information to whole team on progress → provides information to whole team on progress, including any critical steps such as inflation of a balloon in the aorta).

Stage 2: identification of additional endovascular-specific exemplar behaviours

The real-time observations (16 hours including anaesthetic, operating, and recovery time; three endovascular aortic aneurysm repairs, including one fenestrated stent-graft), six semistructured interviews, and one focus group were reviewed to identify any additional endovascular-specific exemplar behaviours for inclusion. These behaviours were reviewed against the endovascular modified OTAS (stage 1). Forty-three new exemplars were identified and included in Endo-OTAS. While the majority of identified exemplar behaviours were specific to endovascular, behaviours that were not specific to endovascular procedures were included; these exemplars reflect changing procedures/best perioperative practices since the development of OTAS, for example "nursing team engage in the completion of the World Health Organization checklist".

Stage 3: assessment of content validity via expert consensus

I-CVI. A summary of the I-CVI results across operative stage and teamwork behaviour are presented in Table 1. Full I-CVI

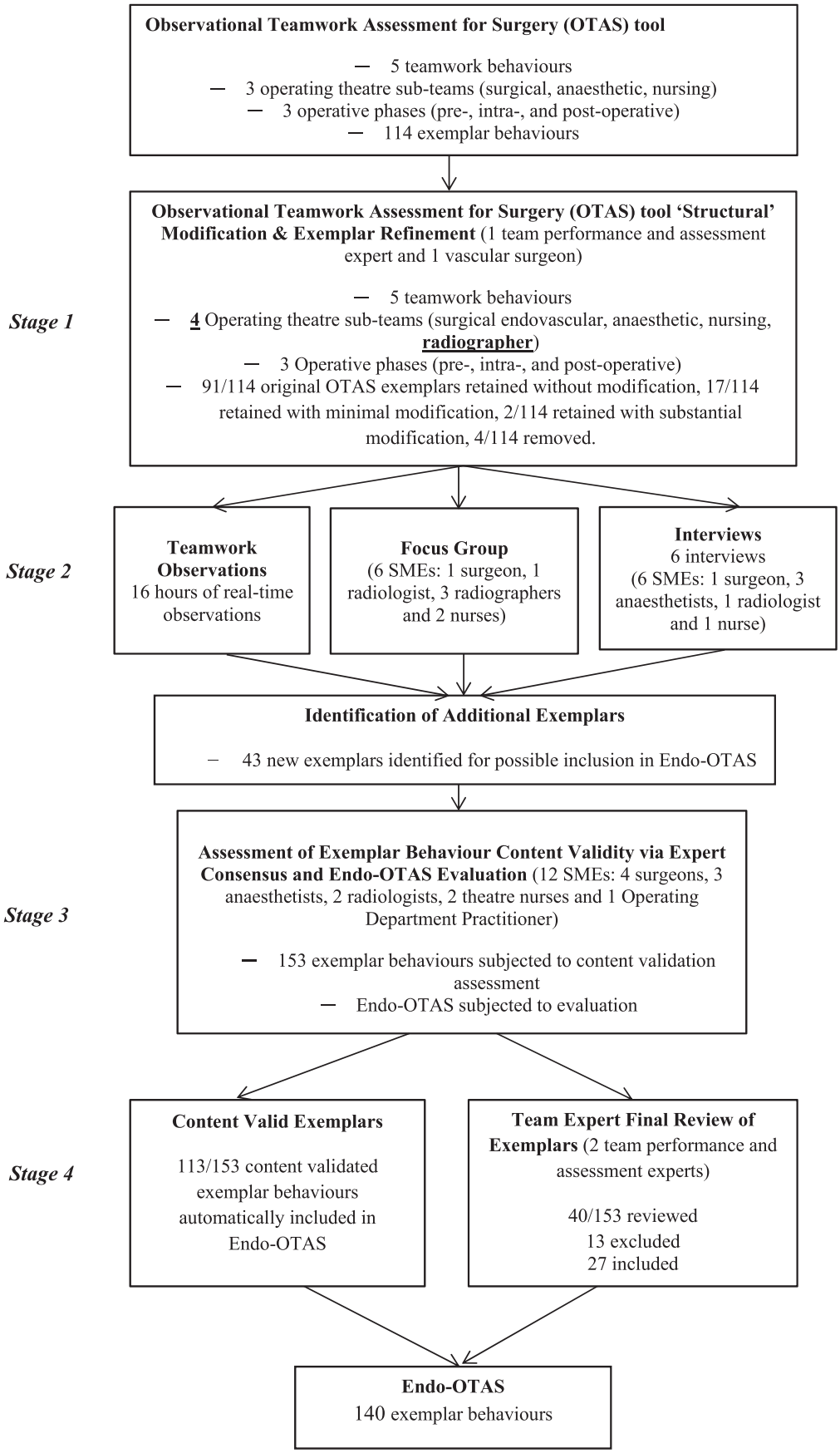

Figure 1. Development and content validation process of the Endovascular Observational Teamwork Assessment for Surgery (Endo-OTAS) tool. *Note*. SME = subject matter expert.

results for all 153 exemplars are presented in Supplementary Tables 1–3. Seventy-two of 153 (47.1%) exemplar behaviours reached and exceeded the predetermined I-CVI criteria ($\geq$ 0.78) on both dimensions assessed, indicating that experts deemed the behaviours highly important to both teamwork and patient safety. In total, 101/153 (66.0%) exemplar behaviours reached and exceeded the predetermined teamwork I-CVI criteria ($\geq$ 0.78). Eighty-three of 153 (54.2%) exemplars reached and exceeded the predetermined patient safety I-CVI criteria ($\geq$ 0.78). In total, 113/153 (73.9%) exemplar behaviours met the predetermined I-CVI on both or one of the two dimensions assessed and were automatically retained for inclusion in Endo-OTAS.

In total, 40/153 (26.1%) exemplar behaviours failed to reach the predetermined I-CVI on both dimensions (i.e., I-CVI $<$ 0.78). These 40 exemplars (listed in Table 2) were therefore not automatically included in Endo-OTAS but further reviewed by the team experts in stage 4.

Evaluation of Endo-OTAS. Most elements regarding the structure and content of Endo-OTAS were viewed favourably by experts (e.g., $>$ 90% of experts agreed that the structure and wording of Endo-OTAS are clear and the behavioural exemplars are observable and useful to guide teamwork evaluations). A high degree of acceptability was expressed by experts in relation to Endo-OTAS, for example $>$ 90% agreed that the quality of teamwork in the operating theatre should be measured and that Endo-OTAS is an appropriate teamwork assessment tool. The majority of experts ($\geq$ 75%) regarded Endo-OTAS as a valuable tool for the evaluation of the quality of teamwork in clinical and simulation-based training and assessment. However, 25% of experts expressed that they would feel uncomfortable with the presence of an Endo-OTAS observer during procedures. Experts perceived Endo-OTAS to be a useful tool self-reflecting, structuring feedback, and auditing teamwork performance. Concerns regarding the feasibility of implementing Endo-OTAS expressed by some experts centred on barriers to implementation.

Stage 4: final team experts' review

Six exemplar behaviours that obtained "very low I-CVI values" for teamwork and patient safety were excluded from Endo-OTAS (displayed in italics in Table 3). Of the remaining 28 exemplars, 24 were included and four exemplars were excluded.

Endo-OTAS. The final Endo-OTAS tool contains 140 content valid exemplar behaviours and is presented in Supplementary Fig. 1.

DISCUSSION

The present study provides a teamwork assessment tool designed specifically to capture the quality of endovascular surgical teamwork: Endo-OTAS. This tool has been developed using established methods and subjected to systematic SME content validity testing and evaluation, with results that suggest this tool is relevant and can be useful in practice.

It is envisaged that the utility of Endo-OTAS will be to offer an applicable framework for accurate evaluation and debriefing of team-working during endovascular procedures. As such, Endo-OTAS has the potential to facilitate

Table 1. Teamwork and patient safety Item-Content Validity Index (I-CVI) across operative stage and Endovascular Observational Teamwork Assessment for Surgery tool behaviour.

	Mean I-CVI teamwork *(min.–max.)*	Number of exemplars failing to reach I-CVI criterion ($<$ 0.78)	Mean I-CVI patient safety *(min.–max.)*	Number of exemplars failing to feach I-CVI criterion ($<$ 0.78)
Operative stage and teamwork behaviour				
Communication exemplars (n = 39)				
Preoperative (n = 11)	0.92 *(0.83–1.00)*	0	0.89 *(0.75–1.00)*	2
Intraoperative (n = 18)	0.83 *(0.58–1.00)*	6	0.82 *(0.50–1.00)*	8
Postoperative (n = 10)	0.91 *(0.82–1.00)*	0	0.90 *(0.67–1.00)*	1
Leadership exemplars (n = 30)				
Preoperative (n = 12)	0.81 *(0.58–1.00)*	5	0.81 *(0.50–1.00)*	5
Intraoperative (n = 12)	0.87 *(0.67–1.00)*	2	0.77 *(0.58–1.00)*	6
Postoperative (n = 6)	0.87 *(0.75–0.92)*	1	0.94 *(0.90–1.00)*	0
Coordination exemplars (n = 34)				
Preoperative (n = 13)	0.66 *(0.27–1.00)*	9	0.66 *(0.33–0.92)*	10
Intraoperative (n = 15)	0.77 *(0.42–1.00)*	6	0.68 *(0.33–0.92)*	12
Postoperative (n = 6)	0.74 *(0.50–0.92)*	3	0.76 *(0.50–0.92)*	2
Cooperation exemplars (n = 26)				
Preoperative (n = 6)	0.83 *(0.58–1.00)*	2	0.78 *(0.42–1.00)*	3
Intraoperative (n = 12)	0.85 *(0.64–1.00)*	3	0.78 *(0.45–1.00)*	5
Postoperative (n = 8)	0.83 *(0.67–0.92)*	1	0.76 *(0.50–1.00)*	4
Team monitoring exemplars (n = 24)				
Preoperative (n = 8)	0.65 *(0.42–0.92)*	6	0.75 *(0.42–1.00)*	5
Intraoperative (n = 11)	0.75 *(0.50–0.83)*	4	0.81 *(0.58–1.00)*	5
Postoperative (n = 5)	0.71 *(0.58–0.91)*	4	0.80 *(0.58–1.00)*	2
Grand total (n = 153)		**52**		**70**

Table 2. Evaluation of the Endovascular Observational Teamwork Assessment for Surgery (Endo-OTAS) tool.

	Number of experts that agreed/ strongly agreed (%)
Structure/content	
The structure of Endo-OTAS is clear	11/12 (91.7)
The layout seems clear for rating purposes	6/12 (50.0)
The five teamwork behaviours are:	
– clear in terms of wording	12/12 (100.0)
– appropriate for measuring teamwork	7/12 (58.3)
– too many	5/12 (41.7)
– too few	1/12 (8.3)
The behavioural exemplars are:	
– clear in terms of wording	9/12 (75.0)
– useful to guide behavioural ratings	11/12 (91.7)
– observable	11/12 (91.7)
– too many	7/12 (58.3)
The length of the Endo-OTAS form is too long	6/11 (54.5)
Acceptability and value of Endo-OTAS	
Effective teamwork is important in endovascular surgery	12/12 (100.0)
The quality of teamwork in theatre should be measured	11/12 (91.7)
Endo-OTAS is an appropriate assessment tool to measure the quality of teamwork in endovascular surgery	10/11 (90.9)
Endo-OTAS would be a valuable measure of teamwork for **clinical:**	
– training	11/12 (91.7)
– assessment	12/12 (100.0)
– accreditation	10/12 (83.3)
– revalidation	9/12 (75.0)
Endo-OTAS would be a valuable measure of teamwork for **simulation-based**:	
– training	11/12 (91.7)
– assessment	11/12 (91.7)
– accreditation	10/12 (83.3)
– revalidation	9/12 (75.0)
I would feel comfortable with the presence of an Endo-OTAS observer during procedures I am involved in	9/12 (75.0)
Usefulness of Endo-OTAS	
Endo-OTAS is a useful tool for self-reflection regarding how I perform as a team member	10/12 (83.3)
Endo-OTAS is a useful tool to structure feedback to trainees on their teamwork skill development	10/12 (83.3)
Endo-OTAS is a useful tool to:	
– identify good teamwork performance and share best practices	11/12 (91.7)
– identify poor teamwork performance	10/12 (83.3)
Giving teams Endo-OTAS feedback on their teamwork during a procedure would be useful for improving the quality of teamwork in theatre.	6/12 (50.0)
Endo-OTAS is a useful tool for research *e.g. how team performance impacts patient safety, whether a team training intervention is successful*	12/12 (100.0)
Endo-OTAS is a useful tool to audit the quality of teamwork in endovascular surgery	9/12 (75.0)
Interest/feasibility of Endo-OTAS implementation	
I would be interested in implementing Endo-OTAS in clinical practice	7/12 (58.3)
I would be interested in attending a training course to train as an Endo-OTAS observer	5/12 (41.7)
Endo-OTAS is feasible to implement considering:	
– time taken to conduct observations	4/12 (33.3)
– time taken to provide feedback based on observations	5/12 (41.7)

improvements in interdisciplinary team performance and patient safety. Endo-OTAS can be used in a number of ways to achieve these goals. Endo-OTAS can be implemented by clinical trainers or team leaders (senior members of the endovascular team) to structure and provide comprehensive feedback/debriefing to teams on their teamwork. Further, Endo-OTAS contains a comprehensive list of "exemplar behaviours" that indicate effective teamwork; teams can use the instrument to identify best practices, which they can then adopt. We envisage that endovascular teams could facilitate such improvements by using Endo-OTAS as a means of structuring self-reflection and team-reflection on how they perform effectively as a team. This tool may be used to identify positive aspects of performance, which can be reinforced, and areas for potential improvement. Using Endo-OTAS as a guide, endovascular teams will be equipped with the means to develop structured and tailored team training to meet their individual needs as a team; rather that adopt a team training programme as a one-size-fits-all, teams are able to develop team training targeting team behaviours that require improvement. The use of Endo-OTAS is compatible and can be used in addition to mandated safety tools, such as the Joint Commission's Universal Protocol in the United States and the World Health Organization surgical safety checklist in the UK, to reinforce the value of working as a team in the endosuite.

Some experts in this study expressed concerns about the time required to conduct observations using Endo-OTAS and to provide feedback. However, investment in teamwork training and assessment should be considered against the backdrop of increasing evidence of the keystone importance of teamwork skills in the optimisation of patient safety and operative outcomes.[2,3] A recent review focused on improving safety in perioperative care specifically highlighted team-based improvements, through both simulation and also team observation, reflection and feedback, as a key vehicle for better care delivery and associated patient outcomes.[19] In addition to the benefits of improving team performance and better patient outcomes, there are many other advantages of improving interdisciplinary teamwork. Another review of the literature examining teamwork in

Table 3. Exemplars failing to reach the predetermine Item-Content Validity Index (I-CVI) criterion for teamwork and patient safety (stage 3) and submitted to team expert review for consideration for inclusion/revision/exclusion (stage 4).

Operative stage, team behaviour/subteam	Exemplar behaviour	Teamwork I-CVI	Patient safety I-CVI	Stage 4 outcome
Pre, S, Coord	6. Arrive in preparation for patient entry to theatre and set up	0.50	0.45	Excluded
Pre, S, Coord	*8. Scrub while nursing team and anaesthetic team complete patient set-up*	*0.27*	*0.45*	Excluded (very low I-CVI)
Pre, S, Coop	*10. Provide assistance in patient set-up*	0.58	0.42	Excluded (very low I-CVI)
Pre, S, Team M	15. *Monitor progress of anaesthesia*	0.42	0.75	Excluded (very low I-CVI)
Pre, S, Team M	16. Monitor final stages of patient and equipment set-up	0.58	0.75	Included
Pre, S, Team M	17. Reassess set-up and intraoperative requirements in advance	0.58	0.50	Excluded
Pre, N, Coord	21. Prepare trolley and theatre in readiness for operation	0.67	0.67	Included
Pre, N, Coord	22. Scrub nurse prepared for operation waiting in prep room to maintain sterility	0.42	0.75	Excluded (very low I-CVI)
Pre, N, Coord	23. Final arrangements of equipment and provisions as surgeons finish set up	0.42	0.58	Excluded (very low I-CVI)
Pre, N, Coop	25. Provide support and assistance to anaesthetic team when needed	0.75	0.67	Included
Pre, N, Coop	*26. Help surgeons with gowns and dress patient in preparation for operation*	*0.42*	*0.33*	Excluded (very low I-CVI)
Pre, N, Lead	28. Provides supervision for junior staff	0.58	0.67	Included
Pre, N, Lead	29. Ensures the surgical endovascular team are available for the start of the case	0.58	0.58	Excluded
Pre, N, Lead	30. Scrub nurse orientates circulating nurse of arrangement of equipment in the room prior to procedure	0.67	0.50	Included
Pre, N, Team M	*31. Monitors progress of equipment set-up and anaesthesia progress*	*0.42*	*0.42*	Excluded (very low I-CVI)
Pre, N, Team M	32. Reassesses intraoperative requirements in advance	0.67	0.75	Included
Pre, A, Coord	37. ODP and anaesthetist present when patient enters the operating theatre	0.75	0.58	Included
Pre, A, Coord	38. ODP prepares the drugs and hands the equipment to the anaesthetist in a timely fashion for anaesthesia to progress smoothly and in a coordinated manner	0.67	0.75	Included
Pre, A, Coop	40. Provide timely information on request from nursing team	0.58	0.67	Included
Pre, A, Lead	43. Questions asked about drugs and antibiotics to surgical endovascular team	0.67	0.75	Included
Intra, S, Coord	*61. Prepares screen, C-arm, and fluoroscopy machines in preparation for procedure*	*0.50*	*0.33*	Excluded (very low I-CVI)
Intra, S, Coord	63. Ensures correct marking of critical anatomical landmarks on angiogram if applicable	0.58	0.75	Included
Intra, S, Lead	71. Advises anaesthetic team or nursing team to call for additional help if required	0.75	0.75	Included
Intra, N, Coord	83. Circulating nurse check provisions prepared and ready for scrub nurse during operation	0.67	0.67	Included
Intra, N, Lead	89. Minimises noise and distractions in theatre	0.67	0.58	Included
Intra, N, Team M	91. Scrub nurse observes procedure closely	0.50	0.58	Excluded
Intra, N, Team M	92. Circulating nurse monitors the needs of the scrub nurse and responds appropriately	0.67	0.58	Included
Intra, A, Team M	94. Enquires about progress of operation	0.75	0.58	Included
Intra, A, Coord	97. Ready for operation when surgical endovascular team are ready to operate	0.75	0.58	Included
Intra, A, Coop	101. ODP acts on requests and inquiry from team	0.73	0.73	Included
Intra, A, Team M	105. Checks and refines set-up	0.75	0.75	Included

Continued

Table 3-*continued*

Operative stage, team behaviour/subteam	Exemplar behaviour	Teamwork I-CVI	Patient safety I-CVI	Stage 4 outcome
Intra, R, Comm	108. Introduces self to team	0.73	0.55	Included
Intra, R, Comm	111. Before leaving theatre, discusses and agrees with surgical endovascular team further imaging requirements	0.60	0.50	Included
Intra, R, Coord	112. Present to discuss and assist in patient positioning with respect to imaging equipment	0.73	0.64	Included
Intra, R, Coop	115. Remains available to assist teams in moving equipment	0.64	0.45	Included
Post, S, Coord	122. Available to assist in patient transfer to trolley	0.67	0.50	Included
Post, S, Coop	123. Remain to help with safe patient transfer to trolley	0.67	0.50	Included
Post, S, Team M	127. Monitors patient transfer to trolley and exit	0.58	0.58	Included
Post, N, Coord	*131. Immediate dismantle and removal of instruments and equipment before patient exit*	*0.50*	*0.50*	Excluded (very low I-CVI)
Post, N, Team M	139. Monitor handling of specimens and their labelling	0.67	0.67	Included

Note. Pre = preoperative stage; Intra = intraoperative stage; Post = operative stage; S = surgical endovascular team; A = anaesthetic team; N = nursing team; R = radiographer; Comm = communication; Lead = leadership; Coop = cooperation/back-up behaviour; Coord = coordination; Team M = team monitoring/situational awareness; ODP = Operating Department Practitioner.
Note. Entries in italics are exemplars that obtained "very low I-CVI values" for teamwork and patient safety and were excluded from Endo-OTAS.

"dynamic domains" of healthcare,[20] such as the operating theatre, found that healthcare providers' perception of the quality of teamwork and leadership is associated with staff well-being, such as emotional exhaustion, burnout, job satisfaction, and organisational commitment—all of which are likely to have financial implications.[20]

The endovascular arena has the opportunity to draw important lessons learnt from other high-stakes fields that have been similarly challenged by efficient and effective implementation of rapid technology advances, for example aviation, military combat, and the nuclear industry. Despite obvious differences between surgery and, for example, the aviation industry, there is strong evidence that adverse events in both industries are frequently associated with breakdowns in teamwork. In all the aforementioned fields, synthesis of individual behaviours into high level functioning teams has been shown to be paramount to fully exploit the potential of technological innovation and to maximise outcomes. The next generation vascular treatment is likely to involve more complex technological advances, for example real-time fusion imaging and robotic navigation, which will require not only novel technical skills, but also robust nontechnical skills to bridge the performance gap.

This study has limitations, including the small number of endovascular centres involved in the development of Endo-OTAS, as well as the overall relatively small number of experts involved at the different study phases. However, 12 SMEs assessed the content validity of Endo-OTAS, which is in line with recommendations that the first iteration of expert content validation review should ideally consist of 8—12 experts.[18] Although SMEs from three centres participated in the validation of the tool, it was not possible to obtain data and opinion from other countries and continents, where practices may differ. Furthermore, the focus group, semistructured interviews, and real-time observations conducted to identify endovascular specific exemplar behaviours (stage 2) were all conducted at one centre. Although the tool may be used pragmatically, Endo-OTAS may require further modification to reflect team composition and teamwork behaviours in particular centres. Lastly, only endovascular aneurysm repair (EVAR) procedures were observed (stage 2). Ideally, we would have observed other endovascular procedures in addition to EVAR. However, a multimethod approach to identify exemplar behaviours relevant to endovascular procedures (interviews and a focus group) and the fact that SMEs were briefed to judge whether the exemplars behaviours were relevant to endovascular procedures, not specifically EVAR procedures (stage 3), we can be confident that Endo-OTAS is applicable to a wide range of endovascular procedures and not just EVAR.

A number of experts expressed concerns regarding the length of Endo-OTAS and this may have implications regarding the perceived complexity of the tool. The 140 exemplar behaviours contained in Endo-OTAS are not meant to serve as a checklist nor are they to be rated individually. (See footnote of Supplementary Fig. 1). Rather, the exemplars are to guide overall teamwork rating. This is important to note as implementing Endo-OTAS in practice may be unwarrantedly interpreted as unfeasible owing to the amount of metrics to be recorded/assessed. Faculty training in applying Endo-OTAS is likely to address such issues and concerns.

Endo-OTAS is in the very early stages of development and although assessing content validity is one of the most critical steps in instrument development,[21] Endo-OTAS requires further validation: construct validation, feasibility, and usability will be assessed through both real-time observation of "live" procedures and evaluation of videotaped simulated

procedures. In addition, it is important to note that accurate assessment of the quality of teamwork is a skill; although endovascular teams were not trained to use Endo-OTAS in the present study, guidelines and recommendations on training requirements are available.[22] Hence, individuals intending to use Endo-OTAS should receive training to ensure assessments are reliable and valid.

CONCLUSIONS

Endo-OTAS is a novel teamwork assessment tool, consisting of five core team behaviours for endovascular surgery, expressed as 140 specific content valid behavioural exemplars. Endo-OTAS could be used for objective assessment of the quality of teamwork during endovascular procedures, team feedback, and prospective improvement.

CONFLICT OF INTEREST

Sevdalis is the Director of London Safety & Training Solutions Ltd, which provides consultancy and advisory services on patient safety, quality improvement, and training to hospitals internationally.

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APPENDIX A. SUPPLEMENTARY DATA

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.ejvs.2015.12.044.

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COUP D'OEIL

Post-traumatic Aneurysm of the Left Internal Carotid Artery

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A 32-year-old male patient was admitted because of loss of vision in the left eye, loss of power of the right leg, and loss of sensitivity of the right arm after a bicycle accident. Ultrasound showed a traumatic dissection of the left internal carotid artery. Symptoms improved under medical therapy. Control ultrasound after 6 months and MRA of the cervical vessels were performed showing a 2-cm pseudoaneurysm of the left internal carotid artery (LICA). Surgical correction with LICA replacement using a great saphenous vein segment was performed successfully.

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